

➤ Second Law of Thermodynamics

The second law of thermodynamics states that it is impossible to convert the heat completely into work without leaving some effect elsewhere.

The second law of thermodynamics is actually a rational solution to the limitations of the first law. For instance, the first law talks about the exact equivalence between heat and work, but it is quite far from reality. In 1824, a French scientist Sadi Carnot showed that for every heat engine there is an upper limit to the efficiency of conversion of heat to work. In order to illustrate Carnot's conclusion, consider a locomotive engine that is supplied with a certain amount of heat; however, all of that heat will not be used to move the train but a part of it will always be consumed in some other processes like overcoming the friction. Let q_2 be the heat absorbed by the heat engine at temperature T_2 , and w is the amount of the work done by the system; while q_1 is the heat returned to the sink at temperature T_1 , then the Carnot's formulation can be given as:

$$\eta = \frac{w}{q_2} = \frac{q_2 - q_1}{q_2} = \frac{T_2 - T_1}{T_2} \quad (9)$$

Where η is the efficiency of the heat engine and is always less than one. Ideally, $\eta = 1$, which means that such a heat engine would convert 100% of the heat absorbed into work.

One more limitation of the first law is that it does not tell about the feasibility of the process, like whether the heat can flow from cold terminal to the hot one or not. It simply talks if the heat gained or heat lost but not the direction of the process. The second law of thermodynamics states that all the spontaneous processes are thermodynamically irreversible. The word "spontaneous" simply means a process that occurs by itself and external drive is required. In other words, we can also say that heat cannot flow from a cold body to hot, the water cannot uphill without any external drive.

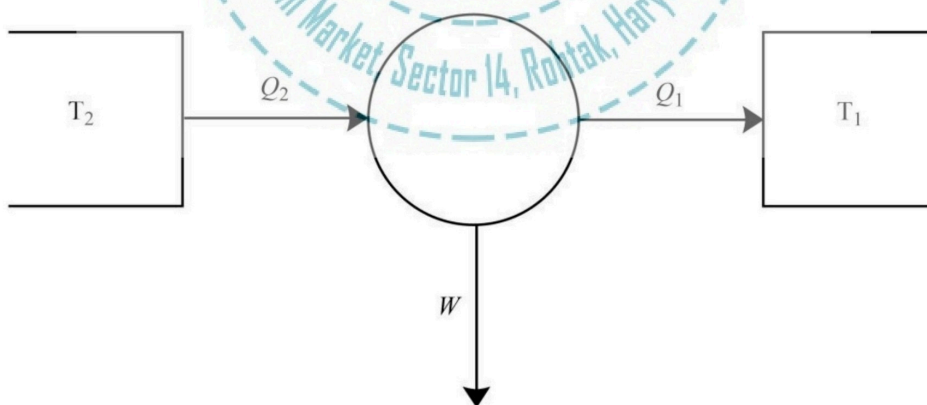


Figure 2. The pictorial representation of the second law of thermodynamics.

The 2nd law of thermodynamics also states that the total entropy of an isolated system can never decline with time; in other words, combined entropy of a system and surroundings remains constant in ideal

cases where the system is undergoing a reversible process. In all processes, including spontaneous processes, that occur, the total entropy of the system and surroundings increases and the process is irreversible in the thermodynamic frame. The entropy-increase accounts for the irreversibility of all the natural processes, and the asymmetry between the past and the future. Overall, the 2nd law of thermodynamics can be labeled as an empirical finding that was accepted as a truism of thermodynamic theory. The microscopic origin of the law can be explained by statistical mechanics.